Cumming (Wm. H.)

Natural and artificial lactation

Extracted from The American Journal of the Medical Sciences for April, 1858.]

NATURAL AND ARTIFICIAL LACTATION.

By WM. HENRY CUMMING, M. D.

Food is necessary to the growth and development of plants and animals. Generation, then, is not merely the quickening of a germ; it requires for its success, a supply of material to be appropriated by the germ, in building up its proper organization. In most animals, the yolk furnishes a limited amount of nourishment, usually exhausted before the young animal has reached that stage of development at which he can use the ordinary food of his race. This deficiency of the yolk-food is supplied in various ways in the various classes of animals.

Insects furnish to their young very little yolk-food. The larva is very far from the perfect development of his kind; but, having a powerful digestive apparatus, and finding food near, he eats, and thus obtains materials for further growth. Having done this, he becomes a pupa, re-entering thus the embryotic state, and there completing his development, comes forth the perfect insect.

We have said that he finds food near. This may occur in different ways. The silk-moth lays her eggs upon the mulberry-tree; the larva feeds upon its leaves. He eats enormously, sheds his skin several times, attains at length his full growth, spins his cocoon, and then in the stillness of apparent death, carries on those further changes, for which ample materials have been secured during the larva state.

The bee, on the other hand, lays up in cells an abundant provision for the larva, by which he is carried through his later transformations.

Many insects deposit their eggs in the water. The larva there finds himself surrounded by smaller organisms, which he devours. The larva of the musquito is an example of this mode of nutrition. Having passed through the necessary changes, he leaves the water, spreads his wings, and thenceforth lives by sucking the juices of plants and animals.

In the frog, the yolk-food is very small, and the tadpole, a little fish-like animal, swimming by means of fins, breathing by means of branchiæ, is very unlike the air-breathing, four-legged, leaping, insect-catching parents. He is in truth a reptilian larva; he eats largely, and grows rapidly; without becoming torpid and inactive, he undergoes great changes of structure, fitting him for his future mode of life.

Many birds leave the egg in a very helpless state: unable to walk or fly, they are dependent, for a longer or shorter period, on parental care. The parents supply them with worms, grubs, insects, &c. Some birds feed their young by vomiting into their open mouths half-digested food.

The gallinaceous birds here deserve especial notice. Many of them leave the egg in a state of entire independence of the mother for food. The yolk-food has in these cases sufficed for the entire development of the bird to this advanced stage.

The eggs of insects are deposited in various localities; some left on trees, some buried in the earth, some dropped in the water, some carefully deposited in cells. There is one other mode which must now be mentioned. The bot-fly deposits her eggs upon the legs of horses, so that they may be licked off, and thus carried into the stomach; there, under the influence of heat and moisture, they are quickly hatched, and the larva being provided with hooks, fixes himself firmly to the walls of the stomach, in which situation he lives by endosmosis. Having thus accumulated a sufficient amount of material for further development, he lets go, and is carried along with the refuse food, and discharged from the body of the animal, to undergo his further transformations in a different locality.

Now, in the case of this insect, there is a striking analogy with the second stage of mammalian development; the egg leaves the ovary, but instead of being laid upon the earth, or in the water, a warm place is provided for it in the midst of a highly vascular organ. Its yolk-food is soon exhausted, but not before another mode of supply has been found. It has no hooks, with which to fasten itself to the walls of its new abode, but it is upheld by the decidua, until other arrangements are made. The villous prolongations of the chorion increase its absorbing surface; and here for various terms, in various animals, it grows by endosmosis from the mother's blood. Various modifications of this process are found, and various degrees of development are thus attained. In no case, however, does it proceed so far as in the gallinaceous kinds; no one of the mammalia is at birth independent of the mother for food.

To those who have observed the various domestic animals, this difference of development at birth is familiar; the calf, the colt, the pig, the kitten, the rabbit, the rat, are well-known instances. But we have not yet reached the lowest extreme of intra-uterine development; far below, among the implacental mammalia (the monotremata and the marsupials), we find the embryo driven forth from the womb, after a short stay, and rudely and perilously (as we should think), transferred to a new abode, and to a new mode of nutrition. We have spoken of the tadpole as a reptilian larva; here we may fairly say that we have found one among the mammalia. This embryo has just one-thirtieth of the adult length, and five hundred-thousandths (.00005) of the usual adult weight. These proportions would be represented by a human embryo 2¼ inches long, and weighing 48 grains. The human embryo at three months is certainly much more developed than the young marsupial at birth. And having now done with external endosmosis, he must *drink* for his life. The nipple does not merely conduct the milk into his mouth, but forces it by muscular contraction into his stomach, deglutition being impossible in his low condition. As in his previous state, the mother's blood was brought into contact with the absorbing chorion, so now is the mother's milk, without any effort on his part, presented to the absorbents of the stomach. In view of his rudimentary state, a wonderful provision has been made whereby he still receives warmth from his mother's body; the marsupial sack contains and shelters him. Thus cherished and nourished, he is safely carried on to the independent state.

And here let us pause and look at this marsupial embryo, that we may see what lactation is. He has advanced about one-fifth of the way from cônception to the independent state; four-fifths of the journey are yet before him. His sole reliance now is on his mother's milk. Not only must the milk do for him what it does for other animals, but it must perform the far more delicate and difficult work of bringing him through the intermediate embryotic condition. Here, then, in the marsupial, we see lactation in its highest manifestation. Here, too, we see plainly that it is the complement of ovarian and uterine nutrition, and that it must therefore vary in extent and influence inversely with the sum of these.

The nutrition of the germ, until it has reached the independent state, is thus seen to be carried on in four ways:—

1st. Simply as in the chicken, by absorption of the yolk-food.

2d. The yolk-food being insufficient, by means of additional nutriment furnished by the parents, as among the greater number of birds.

3d. The yolk-food being very small, by additional nutriment obtained by the larva during his active term. This mode we have found among reptiles as well as among insects.

4th. The yolk-food being very small, nutrition is carried on by two additional processes, in both of which the nutriment is obtained from the body of the mother:—

1. By intra-uterine endosmosis.
2. By lactation.

These four modes may be thus indicated:—

1st. The ovarian.
2d. The ovarian and parental.
3d. The ovarian and larval.
4th. The ovarian, uterine, and mammary.

Lactation is confined to the last of these four classes. The facts relating to the other classes have been presented, that, by a wider induction, we might rise to a higher generalization, and view lactation as it appears to the general physiologist. We could not otherwise discern the exact aim and consequent extent and limits of this function, confined as it is to a few of the higher animals. Its object is now seen to be to carry on the work of development and nutrition commenced in the ovary and continued in the womb. We find it varying in extent and influence from the well-developed ruminant to the helpless, unformed embryo of the marsupial tribes.

What, then, is lactation, regarded as a function intimately connected with the development of the more highly organized animals? It is a part of the great process of generation, occupying from one to four-fifths of the entire period during which the quickened germ is dependent on the mother's body for nourishment. During its continuance, the increase in weight is from threefold to five hundred. It receives the fœtus in the condition and at the stage to which the uterus has carried him, and furnishes the materials necessary for his further growth and development.

But this is not all that lactation does. The most evident peculiarity of animal existence in the higher classes is voluntary motion and bodily activity. These demand large supplies of food. All movement in animals involves decomposition of the structures. To repair these losses, food is needed in much larger quantity than for the mere increase of the body. The ovarian and uterine life differs but little from vegetable existence. But when the young animal is driven forth from the womb, he enters upon a career of movement and activity. The respiratory movements must take place at birth, and gradually the voluntary muscles begin to act, and this action continues steadily to increase. The demand for nutriment is then much greater, during the period of lactation, than in the previous stage. The increase of the body is positively much greater, and the wants of an ever-growing activity greater still.

But we have not yet told all that lactation does. In the higher animals, the vital heat must be maintained in order to have vigour and activity. The temperature of the body must not fall below 100°, even when the external temperature is 150° lower. While yet in the womb, the fœtus partook of the mother's heat, and as there was no material increase of her own external surface, there was no necessity for any serious increase in the activity of her own heat-evolving functions. But now the young animal, with his proportionally immense radiating surface, is placed in the midst of very different circumstances. He has been introduced, perhaps, into an atmosphere the temperature of which is 75°, or 25° below his own standard. Perhaps, on leaving the womb, he finds himself floating in the waters of the frozen ocean. His heat must now be supplied from his own organization; he can no longer depend upon his mother's body for warmth. The internal combustion began with his first breath. In order to its continuance, food must be supplied, containing oil, that, by the proper chemical union with the oxygen of the air, heat may be evolved sufficient to sustain his temperature. Without this fuel-food, the internal combustion will decline, the temperature of the body fall, and languor and death must follow.

In view of these things, we may now say what lactation is. It is the function by which food is supplied to the new-born child: food for growth; food for development; food to repair the losses caused by vital activity; food to furnish fuel for the internal combustion.

As a food-supplying function, therefore, it is the most efficient in the whole course of the generative process. No such demands are made by the fœtus on the mother's energies during the previous stages. Materials for growth are almost all that he needs until birth. But from this time onward until able to use the ordinary food of his kind, he looks to the mother for that nourishment which will enable him to maintain his temperature, to move, and to act.

The organs of this function are the mammary glands. They are found under many varied forms, from the cæcal follicles of the ornithorhynchus to the elaborate and complex mamma of the higher animals.

These organs have an intermittent functional activity. It does not at first commence until the termination of the previous stages of the generative process. It continues until its work is finished, or until another generative process begins.

The product of this mammary secretion is milk. Let us examine its physical and chemical qualities, that we may see its fitness to perform the great work of nutrition.

First, it is liquid, and can therefore be drawn from the gland in such quantity as is needed at the time. Its liquidity is indispensable, too, that it may be received by the young animal and swallowed. In some animals, it must, in addition, be injected by muscular contractions into the stomach of the young.

Second, its temperature is that of the body of the mother, and consequently it has no chilling influence upon the stomach of the child.

Nor are its intimate structure and chemical constitution less suited to the wants of the young animal. Of these wants, the first in order of time is warmth. The radiation from his relatively extensive surface would soon lead to fatal results were there not a constant evolution of heat within. The milk supplies this fuel-food in such abundance that it is not usually all consumed. Accumulations of fat, the indices of this excess above the immediate wants of the young animal, commonly take place. His genial warmth and vital activity indicate the same sufficiency. Accurate observation shows that the temperature of the blood is fully maintained.

The next want of the young animal is material for growth and development. This material, needed from the moment of impregnation, has been previously derived first from the yolk-food, and afterwards from the mother's blood. It is evident that the yolk-food of the chicken must contain all the elements necessary for the formation of the body of the bird; the germ, inclosed in the shell, being precluded from all possibility of gaining any other supply. The blood of the mother contains all the elements of her own body, and consequently all existing in the body of the child, and required for its growth and development. The embryo is thus placed, during the intra-uterine period, in close and constant relation with a liquid rich in all the elements of its own organization. These elements are at least sixteen in number, viz., oxygen, hydrogen, carbon, azote, chlorine, iodine, fluorine, sulphur, phosphorus, silicon, potassium, sodium, calcium, magnesium, iron, and manganese. But not only are the elements there, but the organic combinations too, such as the fœtus requires: albumen, globulin, fibrin, hæmatin, margarin, olein, lecithin, cholesterin, serolin, chlorides of sodium and potassium, phosphates of lime, magnesia, potassa, soda, iron, and manganese, fluoride of calcium, and other most useful combinations. Thus placed in the midst of such supplies, the fœtus may well appropriate all the materials that he needs. But the time comes at length for a great change—the fœtus must be driven forth, and his contact with the mother's blood ceases from that hour. And yet his organization is incomplete; his structure is by no means finished. Let us turn to the case of the young marsupial, where the placenta did not exist, and where this uterine endosmosis has lasted only a few days. This rudimentary embryo, now in the marsupial sack, can no more dispense with the sixteen elements of his body than can the fœtuses of other animals during the latter part of their intra-uterine abode. The *blood* of the mother has done but little for him; her *milk* must do the rest, and, constituted as it is by Divine wisdom to suit his need, the young marsupial in all his feebleness is safe. No element of his body is wanting in this wonderful secretion, and forced as it is by muscular contraction into his stomach, rich in all the materials of growth, his progress is rapid to the independent condition. Thus, then, from the necessities of the marsupial we might infer the general composition of milk. But the facts ascertained by chemical analysis far transcend all our conceptions thus acquired. Not only do we find all the elements, but many of them in the same combinations as in the body and blood of the child. Four protein compounds, containing oxygen, hydrogen, carbon, azote, and sulphur, several oils, and more than ten mineral salts, enter into its composition. And what is more remarkable still, one of these salts (phosphate of lime) is found in such combination with these protein compounds, that though itself insoluble, it may be readily absorbed. This union of phosphate of lime in large proportions with casein, with albumen, and with albuminose, is one of the most important and interesting facts in relation to the composition of milk. Indispensable as it is in the formation of teeth and bone, it is thus, notwithstanding its insolubility, freely introduced into the system in an available form.

We have referred to the butter as fuel-food. In cow's milk the butter consists of ten oily substances: olein, butyrin, caproïn, caprylin, caprin, myristicin, palmitin, stearin, butin, and lecithin. In the actual state of chemical knowledge, it is impossible to state the precise use of these several oils. Whether they result from the original differences in the articles of food, but subserve the same purpose in the body, or whether they are there with reference to distinct and peculiar wants of the young animal is not known.

Being deficient in azote, they do not probably contribute directly to the formation of the azotized tissues.

One of these oily substances, however, deserves and must receive more careful consideration. It has long been known that the nervous system has a peculiar constituent, a phosphorized oil. Its origin in the young animal has been discovered by Gobley, who found it in the yolk. So largely does it enter into this that it has been named lecithin. It has been found in human blood in the proportion of five ten-thousandths: in the blood of pregnant women ninety ten-thousandths have been found, and in the blood of the umbilical artery seventy-five ten-thousandths. This oil being the special constituent of the nervous system, is furnished by the blood for the functional use of the system and for its growth. It would therefore soon be exhausted unless a supply from without were obtained. In the event of such a failure, the most serious consequences might be expected. Not only would the nervous system cease to grow and thus lose its relation to the rest of the body, but its activity would decline, and consequently the energy of all the functions. With a failure of nerve-force would coincide a failure of circulation, of heat, of digestion, of absorption, and of secretion. Indeed, every vital process would suffer from the deficiency of this energizing agent. And the evil would go on increasing. A weakened digestion would lead to a still further diminution of the already deficient energy, and thus by mutually depressing interactions, the decline would continue until the termination of life from inanition.[1]

[1] *Conditions of Calorification.*—What are these conditions? They are: 1st. Good air, *i. e.* air containing a due proportion of oxygen. 2d. Good blood, *i. e.* blood containing a sufficiency of combustible material. 3d. A sufficiency of good air in the pulmonary cells. 4th. A sufficiency of good blood in the pulmonary capillaries.—These four conditions are indispensable to full calorification. If the air be deficient in oxygen, or be introduced in too small quantity, it will be in vain that the other two conditions exist. And if there be not enough of fatty matter in the blood, nor a sufficient impulsion from the heart, the former conditions will be of no value. Two of these conditions are chemical, relating to the composition of the air and of the blood; the other two are mechanical, relating to the performance of the respiratory and circulatory acts. These last are under the influence of the nervous system, and will vary with the nervous energy.

If then, heat is to be evolved in sufficient quantity, we must have not only enough oxygen in the air, and enough oil in the blood, but we must have a supply of nervous power to induce free respiration by means of muscular action, and strong contractions of the heart, that the blood may be forced rapidly and readily through the capillaries of the lungs. With full respiration and active circulation, a sufficiency of oxygen will be mingled with the blood to furnish an abundant supply of caloric. With deficient nervous power, this vigorous action of the muscles of respiration and circulation is impossible. All pathological observation settles this point. It is a wonderful fact, that butter contains not only the fuel, but the material necessary for its proper combustion. It is thus a self-regulating article. Is the supply of fuel small, the consuming power is proportionally reduced. With an increase of the consuming power, coincides a proportional increase of the material to be consumed.

From these facts we may readily understand how a child may be fat and yet be deficient in strength and in vital heat. Starch-fed children are often fat, and yet are

But these serious and fatal results cannot occur in a case of normal lactation. The needed lecithin is furnished by the milk in sufficient quantity to supply all the demands of the system. In cow's milk the lecithin forms three thousandths of the whole. A calf obtains from twenty pounds of milk (his usual daily allowance) about one ounce. An infant three months old receives about forty-six grains daily, or two pounds in the first year. This amount, when compared with the quantity existing in the nervous system, is very great. We see then that it must be for the most part expended in nervous action, not in the growth of the nervous system. And who that knows the almost incessant activity of young animals (when awake), can wonder at this large consumption?

The uses of the butter are thus seen to be: to supply fuel for the internal combustion, to furnish oil for the tissues of the body, and to supply the special constituent of the nervous system to be employed in its growth and activity.

So much uncertainty still rests upon the uses of the sugar in the milk, that we leave that matter untouched in this paper. It was once supposed to be merely fuel; but the tendency of physiological research is to assign to it other important uses.

The butter and sugar contain no azote, and are therefore ill-adapted to the development of the tissues of the body, which contain so much of this element. It is not known that the bodies of animals have power to transform an unazotized into an azotized compound. In the present state of chemical knowledge we are led to suppose that azotized combinations must of necessity exist in the food of animals. In milk, they form from one and a half to five per cent. of the whole—or from thirteen to thirty-three per cent. of the solid portion. This statement is made here for the purpose of showing that milk is not the weak food that many suppose. Adults among nomadic tribes depend upon it to a great extent, and find it a strengthening diet. The vigour and rapid development of young animals bear witness to the same truth. Indeed, it may be safely said that under no conditions of life is there so rapid and healthful increase as during the season when milk is the sole article of food.

The duration of this function varies greatly in different animals. In some of the marsupials it lasts four times as long as the term of gestation; in the ruminants only two-thirds as long as gestation. Thus compared, lactation is in the former as twelve, while in the latter it is as two. It is thus six times

languid and weak. The starch has been digested, but as it contained no azote, it could not nourish the tissues of the body; having no phosphorus, it could not supply the wants of the nervous system. It has thus failed to produce heat or general energy. Not so with butter. The lecithin excites the nervous system to efficient action, and all the functions feel its influence. And thus the butter-fed child is often less fat than one fed on starch. But in all that constitutes bodily well-being, he is far in advance.

To promote calorification, there is no equal to butter among the articles of food usually given to infants. It is probable that no substitute for it will ever be found.

as long relatively. And this difference should not surprise us when we consider the different stages of development at which lactation commences in the two classes.

The nature of the usual food of the animal has doubtless an influence on the normal duration of this function. Where this food is difficult of digestion, the young animal must attain more general vigour before he can be safely weaned. The carnivorous and insectivorous animals may therefore be weaned at a relatively earlier age than those using more refractory food.

Normal Lactation in the Human Race.—In vigorous women the secretion of milk is copious. And this large amount is indicated in the unimpregnated state by the great development of the mammary glands. In no animal with which we are acquainted is there a larger promise in this respect. The amount ordinarily furnished by a good nurse is from one and a half to two quarts daily, or from four to five pounds. But cases often occur in which two children receive abundant supplies from one mother, involving a secretion of eight pounds at least. An infant three months old will take from forty-eight to sixty-four fluidounces daily in six or eight half-pint doses. During the first year therefore he will take from 1000 to 1300 lbs.

What is the composition of this milk? Without entering into long and tedious details, it may be simply said that by the latest and apparently the most exact analysis, its composition is:—

Butter	20.76	1000 lbs. therefore contain	Butter 20.76 lbs.	1300 lbs. therefore contain	Butter	27 lbs.
Casein	14.34		Casein 14.34 "		Casein	18½ "
Sugar	75.02		Sugar 75.02 "		Sugar	97½ "
Water	889.88		Water 889.88 "		Water	1157 "

In 1000 lbs. of milk there are 1.6238 lb. of salts, or 26 ounces, of which 0.5736 lb., or 9 ounces, are phosphate of lime.

In 1,300 lbs. of milk the salts amount to 2.1 lbs., or 33½ ounces, of which 12 ounces are phosphate of lime.

It thus appears that, during the first year, the child receives from 110 to 143 pounds of dry solids. He may thus readily gain 15 or 20 pounds in weight (implying less than three pounds of dry solids), and yet have a large residue, from 107 to 140 pounds, to be expended in the production of heat and in the activity of an energetic vitality. A child thus nourished can make teeth and bone without difficulty; his functional activity need never be suspended for want of material; atmospheric changes may be successfully resisted, and zymotic diseases will have little power.

And where, in the whole range of animal existence, will you find a more beautiful object than a vigorous healthy child? Look at his deep and peaceful sleep; see the bright sunshine of a pleasant dream upon his gentle face. Look at him as he awakes. Listen to the sweet sounds he makes for his own pleasure, or to attract the notice of those near. And if he should at last break out into loud cries, see how quickly all traces of sorrow pass away and bright smiles replace them when his mother comes. See the eagerness with which he takes his food; the intense earnestness with which he clings to the abounding breast; and the full and deep satisfaction when this want is supplied. And when able to play, how loud and merry his laugh; how joyfully he receives caresses, or rides upon the knee, or springs in the arms of the parent or the nurse. There is no happier animal than a healthy child; nor is there anywhere to be found a more regularly operating and uninterrupted harmony of the vital functions. The beauty and energy of the outward frame are not more striking than the symmetrical development of the mental powers. The close and careful and patient observation, the cautious experiment, the unsuspecting credulity, the prying inquisitiveness, who has not beheld with admiration and delight?

This is infancy under the influence of favourable physical conditions. But alas! how few children among us progress thus steadily and rapidly during their first two years! How commonly do we associate with infancy the ideas of sleeplessness and fretfulness, and all manner of gastric, intestinal, and nervous disorders! Why is it that "teething" does not mean the steady, silent, unnoticed development of the teeth, but salivation, and fever, and diarrhœa, and convulsions, and death? It is not pretended that there is never any other cause but insufficiency of proper food, but there is reason to believe that four-fifths of the sufferings of infancy arise from this source. And how can it be otherwise? Look at the mothers, and say how many of them can give daily three or four pounds of good milk to their nurslings. How many can furnish 110 or 140 pounds of dry solids in the first year? How many can satisfy, can fully meet the demands of even a feeble child? *A strong, vigorous, fat woman* almost always loses weight while nursing her child. The milk draws away more than the stomach of even such a woman can replace, and the balance is taken by absorption from her previous accumulation.

And here listen to an important practical remark: A woman loses in an ordinary parturition not more than 20 pounds, containing less than 3 pounds of dry solids. This amount furnished in nine months is at the rate of 4 pounds of dry solids a year. Many women fail to furnish fully even this small amount. The infant at birth is small and meagre, looking like a starveling. Is it to be expected that such a mother will make a successful nurse? If unable to furnish this small amount, how can she supply thirty or forty times as much?

The truth is, that a woman in fully nourishing her child, must furnish as much milk in proportion to her weight as a good cow. A woman weighing 130 pounds will give daily 4 pounds of milk, containing about 5 ounces of dry solids; the cow weighing six times as much (780 pounds), will give 20 pounds of milk, containing 30 ounces of the same. It should not then surprise us that so many mothers fail to supply enough food for their infants. It requires great physical energy and powerful digestion to perform this work. How few mothers are thus endowed! If we may judge by the amount of food consumed by a vigorous woman during the period of lactation, we should decide that the ordinary labour of a working man is less exhausting than the function we are considering. Certain it is that a vigorous woman of strong digestion, while nursing a child, will eat largely, and yet lose weight.

The cases in which natural lactation fails are so numerous as to excite the deepest concern. Human milk can seldom be obtained, and none of the usually employed substitutes ordinarily succeed. Is it then too much to hope that physicians will give serious attention and thoughtful consideration to a plan offering a substitute for human milk scientifically correct and practically successful?

From what has been said of the adaptation of milk by its peculiar and admirable constitution to the wants of the young animal, it follows of necessity, that nothing but milk can be proposed as a substitute for the natural food. The only kind that in this country can be readily and certainly obtained, is that of the cow. But the various kinds of milk are not identical in composition, being adapted to the different degrees of development at birth of the young. The ruminants are the most advanced in this respect, the human infant is far behind. It cannot then be supposed that milk adapted to the stomach of a calf would suit that of a new-born child. Common observation agrees with chemical analysis in declaring that there is too much casein in the milk of the cow to be tolerated by the child. This is a well-known fact, and every one waters the milk. But "how much water must be used?" and "will watering do no harm?" are questions to be answered only by careful study of the milk and close observation of its effects upon the child.

Cow's milk contains	Butter . .	38.59	While human milk contains	Butter . .	20.76
	Casein . .	40.75		Casein . .	14.34
	Sugar . .	53.97		Sugar . .	75.02
	Water . .	866.69		Water . .	889.88

Cow's milk, therefore, contains nearly three times as much casein as human milk, but less than twice as much butter. In cow's milk, the butter is to the casein as 100 to 105; in human milk, as 100 to 70. If then, by dilution, we reduce the butter to 20.76, we shall have 21.92 of casein, or 50 per cent. more than in human milk. With such an excess of casein, we cannot hope to succeed. The stomach of the child cannot digest it, and it will thus pass through the intestinal canal, irritating as it goes. Debilitating diarrhœa and, perhaps, vomiting will occur, and the attempt fail. This is the usual experience of those who use cow's milk for infants, and often leads to the abandonment of milk and the substitution of farinaceous food.[1]

[1] The food of infants should be all absorbed. During the fœtal state, the food of the body is obtained by endosmosis from the mother's blood. During the period of lactation, it comes from the mother's milk. In this milk there is no refuse matter; all is absorbed and passes into the circulation. No portion of the milk passes from the stomach through the intestinal canal to the rectum. The feces of infants are the excretions of the intestinal canal and its various glandular appendages. The lower

If, by a further dilution, we reduce the casein to 14.34, we have only 13.58 of butter, or less than two-thirds of the proper proportion. Such milk may for a season seem to suit the child, but before long it will be found that he does not thrive. The reason is plain. The right proportion of butter is 20.76; this warms a child, and supplies nervous energy. But, by witholding one-third, you lower the temperature of the body and deprive the nervous system of one-third of the special nerve-food, the indispensable lecithin. What wonder, then, that in a short time pallor and languor supervene, and the health evidently declines. Continue this food, and there is one result—starvation. Restore the full supply of butter, and, if matters have not gone too far for recovery, warmth and energy will gradually return, the downward progress be stayed, and vigour replace debility.

It is thus evident that by no mode of dilution can ordinary cow's milk be made a substitute for human. There will be in every case an excess of casein, or a deficiency of butter. So long as the butter is to the casein as 100 to 105, instead of as 100 to 70, so long must dilution fail to adapt it to the wants of the child. But if this original proportion could be changed to that existing in human milk, we might have hope of success. And we proceed to show how this may be done.

If we leave at rest for four or five hours ordinary cow's milk, and then remove and examine the upper third, we find in it 50 per cent. more butter than it at first contained. In round numbers, its butter is no longer to its casein as 100 to 105, but as 150 to 105, or as 100 to 70. If then, by dilution of this milk, we reduce the butter to 20.76, we have 14.34 of casein, as in human milk.

Another, and in some respects, a better mode of obtaining the same result is by using the latter half of the milk furnished by the cow. The former half contains 22.18 of butter to 41.63 of casein, while the latter half has 54 of butter to 38 of casein. Here, again, the right proportion exists, and, by proper dilution, may be made most accurately to resemble in its chemical constitution human milk.

To show the accuracy of this imitation, let us prepare some of this milk

part of the canal may thus be considered as the excreting duct of the liver, pancreas, and the glands of the mucous surface.

What wonder, then, that this duct should be irritated by the presence of foreign bodies (lumps of curd, starch granules, &c. &c.), and that this irritation should continue so long as these foreign bodies remain in contact with its surface?

No fact is more interesting and important than this, that persistent diarrhœa often ceases at once when suitable food is given. By suitable food we mean food that is all absorbed. Three or four hours after the first dose of such food, the diarrhœa often ceases entirely.

Bearing this truth in mind, let us never expect health so long as foreign substances are found in the feces of infants. Even small and smooth particles of curd produce great irritation, and, in many cases, the ingestion of such food produces almost immediately a discharge of mucus holding in suspension these offending substances.

by the addition of sugar and water. Its actual composition is butter 54, casein 38, sugar 53, and water 855. By adding sugar 142 and water 1458, we have butter 54, casein 38, sugar 195, and water 2313. Reducing this to thousandths (that we may compare it with the composition of human milk, as previously given), we have butter 20.77, casein 14.61, sugar 75, and water 889.62. The difference is unworthy of notice.

Not only may ordinary human milk be thus closely imitated, but the colostrum also. To do this, during the first month of the child's life, we must use milk containing from 75 to 80 thousandths of butter, or from 94 to 107 per cent. more than the ordinary milk of the cow. This exceedingly rich milk may be obtained by taking the upper *eighth* instead of the upper *third* of milk left to repose for four or five hours. It may also be obtained by using the last *tenth* of the milk furnished by the cow. In the following schedule, the milk of the first month is of this peculiarly oily kind.

It will be seen from this schedule that, by the gradual diminution of water, an attempt is made (in imitation of the natural process) to adapt the food to the growing energy of the child. It will, of course, be understood by every practitioner that, in this schedule, age is used to indicate development. Some children are two or three months behind their age, and must be fed accordingly. In general, it is better to begin with milk more diluted than the age and development would seem to indicate, and then gradually increase its strength. It is better that the food should be insufficient than that it should be indigestible.

Schedule.

For a child from	3 to 10 days old.	Milk 1000	Water 2643	Sugar 243
" "	10 to 30 "	"	" 2500	" 225
" "	1 month old	"	" 2250	" 204
" "	2 months old	"	" 1850	" 172
" "	3 "	"	" 1500	" 144
" "	4 "	"	" 1250	" 124
" "	5 "	"	" 1000	" 104
" "	6 "	"	" 875	" 94
" "	7 "	"	" 750	" 84
" "	9 "	"	" 675	" 78
" "	11 "	"	" 625	" 73
" "	14 "	"	" 550	" 67
" "	18 "	"	" 500	" 63

The infant should take this food by suction. For this there are several reasons. 1st. It is the natural mode; 2d. We cannot otherwise administer the food at so uniform a temperature; 3d. We cannot otherwise secure a free flow of saliva; 4th. We may thus feed the child in the natural posture, the recumbent. There is less danger of regurgitation, and he sinks to sleep quietly after feeding, if the time for sleeping has come.

An eight ounce vial, with a quill rolled in a long strip of Swiss muslin for a stopper, is the best arrangement for cleanliness and convenience. Tubes having narrow passages cannot be realily cleansed.

A child ten days old will take about thirty-two ounces daily in eight four-ounce doses. The doses will increase in size and somewhat diminish in number, so that at three months seven eight-ounce doses are usually taken. The milk should be given at regular intervals; the good effects of method and strict regularity in this matter are very apparent. The child should be early trained to pass six or eight hours at night without feeding. The temperature should be from 100° to 104°. The child should not be allowed to take the milk too rapidly; ten or fifteen minutes should be given to each dose. The stomach will not then be too much distended, the liquid part being quickly absorbed.

This food thus administered may well be styled *artificial human milk.* In chemical composition, it most closely resembles the natural secretion of the mammary glands of vigorous, healthy women, and it offers to the child all that he needs for growth, development, warmth, and activity. A careful observation of its effects for several years has led to the conviction that it leaves nothing to be desired, and that, on this food, an infant may be reared with admirable results. And by this we mean that health, uninterrupted health, with vigour and energy of the bodily functions, may be regarded as the natural result of the use of this food. We mean that gastric and intestinal disorders do not follow its use, as they so often do that of the milk of mothers. We mean that under its use dentition will be ordinarily a painless process, and that the teeth will be strong and durable. Believing that a large proportion of the sickness and death of infants is the result of insufficient and improper food, we feel sure that, by the use of this artificial human milk, the health and lives of tens of thousands might be annually preserved. We believe that, if generally used, the influence upon the next generation would be evident in a visible increase of health and vigour. In our own household it has proved of priceless value, and we desire that other households may share the benefit.

It is an undoubted fact that in many, very many cases, the function of lactation is imperfectly performed. This deficiency arises from two sources, imperfect development of the genital organs (including the mammary glands), and general debility of the vital functions. The season of puberty extending from 13 or 14 to 18 or 20 years of age, is the only period during which the generative apparatus can be well developed. If this season be lost, the evil can never be repaired. The development must occur *then* or *never*. How important, then, that girls should enter upon and pass through this season under the most favourable physical conditions. Good food, good air, sunshine, muscular exertion, everything that tends to bodily vigour, should be secured to them during this period of life. Sedentary occupations, excessive mental exertion, late hours, insufficient sleep, are evidently most unfavourable to development. And yet in this last sentence we have sketched the history of a very large number of girls of all classes. The daughters of the rich give too much time to study, to reading, to music, and the other fine arts, and are thus deprived of sunshine, fresh air, vigorous and invigorating exercise, and consequently of abundant and nutritious food. The daughters of the poor suffer from confinement by needlework or some equally sedentary occupation. The long-continued labour in manufacturing establishments is a fruitful source of this evil. In all these cases the bodily powers are impaired, very little nutriment is obtained, and consequently the great changes belonging to the age of puberty cannot fully take place. The chest and pelvis are not properly developed, the menstrual function is not regularly and fully and painlessly established, and the mammary glands fail to attain their proper size. Nothing is more evident than the truth of these statements. Painless, regular and full menstruation is rarely seen, while irregularity and agonizing pain in connection with this function are very common. In many cases this want of fulness of development is such that marriages are unfruitful, at least for a long time. And when impregnation *does* occur, the period of gestation is one of nausea and lassitude and debility. Abortions frequently take place and impair most seriously the general health. And in more fortunate cases, how often is the child at birth feeble and ill-developed. The mother's strength is still further diminished by the labours, and sufferings, and losses of parturition. Her breasts do indeed become turgid, a milky secretion takes place, but it is miserably insufficient for the child. It continues for a few weeks, and then ceases. Every physician knows these facts by personal observation; they are constantly occurring.

In such cases the child is not suffered to perish without an effort to save him. Occasionally a good nurse is obtained, who can fully supply his wants. But good nurses are rare, and nurses of even an inferior description are not to be found in sufficient numbers to supply one-tenth of the children needing food. Cow's milk is often tried and often abandoned, because of the disorders it produces. Panada, arrowroot, cornstarch, or some other farinaceous food is then used by some mothers, while others use various preparations of flesh in the form of broths. The consequences to the children, of the use of these various articles of food, are most injurious. Pallor, languor, debility, indigestion, vomiting, diarrhœa, painful and difficult dentition, convulsions, marasmus, cholera infantum, and dropsy of the head, are some of the results of this imperfect and improper supply. The feeble infants are unable to resist atmospheric changes, so that the winter's cold and the summer's heat are almost equally injurious, while the starving and wasting body offers to zymotic diseases an admirable nidus. Tubercular deposits frequently take place, and in all these ways the mortality is fearful. Pestilence ever follows close in the steps of famine, and these little starving children are swept off by thousands.

In view of these grave facts, what is our duty as the medical advisers of the people? We should seek to influence by precept and example the parents and guardians who have girls under their care. We should urge them to use every effort for the prevention for the future of these evils, now, alas! so common. We must endeavour to have the next generation of women healthy and vigorous, able to bear children and rear them too, so that they may thrive and prosper.

And in the many cases all around us of children now needing food which their mothers' breasts fail to furnish, we should teach the mothers to prepare such food as is really a substitute for human milk. Turning away from starches and all such innutritious substances, we should show them how to obtain from the milk of animals *true food.* In the country this may be easily done, and mothers should be instructed how to use it, modifying it under medical advice, to suit the age and development of the child.

But what shall be done in cities? Shall the thousands there perish by starvation, or shall they too be fed? Why may not the country supply food for *them* as well as for the rest of the population? True, it will demand care and skill to conduct such an enterprise, but how can care and skill be more usefully employed than in rescuing these little wretches from the doom that awaits them? No physician is so useful as he would be, who should successfully perform this work. "The blessing of him that was ready to perish," would come upon him, and he would cause many a mother's "heart to sing for joy."

The details of this enterprise would be few and simple. The latter half of the milk of the cow should be used for the children, and diluted and sweetened for each child separately. It should then be bottled, and labelled, and addressed. It should be distributed daily. The physician having charge of its administration should visit each child at least twice a month, to ascertain its progress, and direct the composition of the milk in accordance with these observations of his own. Care and skill will here produce admirable results, and no parent, after seeing them, will fail to obtain this food for his hungry little ones.

On this plan the children in cities might be as well fed as those in the country, and much of the dreadful mortality be avoided. How much better this than to spend months of anxiety over a starving child, while the physician is vainly seeking to relieve his sufferings with drugs. He needs butter and casein; give him these in proper combination with sugar and water, and there may be hope. Without these hope is vain.

WILLIAMSTOWN, MASS., *May*, 1858.